ARTICLE

Kangaroo Care Is Effective in Diminishing Pain Response in Preterm Neonates

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Objective: To test the efficacy of maternal skin-to-skin contact, or kangaroo care (KC), on diminishing the pain response of preterm neonates to heel lancing.

Design: A crossover design was used, in which the neonates served as their own controls.

Subjects: Preterm neonates (n=74), between 32 and 36 weeks' postmenstrual age and within 10 days of birth, who were breathing without assistance and who were not receiving sedatives or analgesics in 3 level II to III neonatal intensive care units in Canada.

Interventions: In the experimental condition, the neonate was held in KC for 30 minutes before the heel-lancing procedure and remained in KC for the duration of the procedure. In the control condition, the neonate was in the prone position in the isolette. The ordering of conditions was random.

Main Outcome Measures: The primary outcome was the Premature Infant Pain Profile, which is composed of 3 facial actions, maximum heart rate, and minimum oxygen saturation changes from baseline in 30-second blocks. Videotapes, taken with the camera positioned on the neonate's face so that an observer could not tell whether the neonate was being held or was in the isolette, were coded by research assistants who were naïve to the purpose of the study. Heart rate and oxygen levels were continuously monitored into a computer for later analysis. A repeated-measures analysis of covariance was used, with order of condition and site as factors and severity of illness as a covariate.

Results: Premature Infant Pain Profile scores across the first 90 seconds from the heel-lancing procedure were significantly ($.002<P<.04$) lower by 2 points in the KC condition.

Conclusions: For preterm neonates who are 32 weeks' postmenstrual age or older, KC seems to effectively decrease pain from heel lancing. Further study is needed to determine if younger neonates or those requiring assistance in breathing, or older infants or toddlers, would benefit from KC, or if it would remain effective over several procedures. Given its effectiveness, and that parents of neonates in critical care units want to participate more in comforting their children, KC is a potentially beneficial strategy for promoting family health.

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SKIN-TO-SKIN HOLDING of a newborn, or kangaroo care (KC), named such because of its similarity to marsupial behavior in early life, is gaining acceptance as a standard of care in neonatal intensive care units (NICUs) throughout the world. Findings from a recent survey[1] on holding policy in 215 NICUs in the United States indicated that almost three quarters (73%) allowed parents to hold their extubated neonate in KC. First developed as a method of providing warmth for low-birth-weight neonates, KC originated in Bogota, Columbia, in 1979.[2] During KC, a diaper-clad neonate is held upright, at an angle of approximately 60°, between the mother's breasts or on the father's chest, providing maximal skin-to-skin contact between neonate and parent.

Kangaroo care has had positive effects on autonomic behavior and state. The state dimension of neurobehavioral organization involves the preterm neonate's ability to make smooth transitions between the sleep, quiet, and awake phases, and to maintain the most desirable state of quiet sleep.[3] Several studies[4-8] have shown that 1 to 3 hours spent in KC resulted in increased frequency of quiet sleep, longer duration of quiet sleep, and decreased crying. Preterm neonates of 25 to 36 weeks' gestational age, given unlimited access to KC during their NICU stay, cried less at the age of 6 months than control neonates who did not receive skin-to-skin contact.[9]

Neonates born prematurely who spend the first weeks of their lives in NICUs undergo many invasive procedures (an average of 2-3 per day, up to 8-10

per day) without benefit of analgesia.[10-12] Heel lancing is the most common procedure.[11,12] There is increasing evidence[13-17] to suggest that these repeated invasive procedures have long-term consequences. Given the frequency of painful procedures, the potential negative consequences of experiencing repeated painful procedures, and the potential risks of opiate analgesics for frequent procedural pain,[18] it would seem that nonpharmacological interventions should be tested to control for procedural pain.[19] Pain decreases state regulation,[20] and KC has been shown to improve state regulation.[3] Sleep state has been associated with decreased pain response,[21,22] and KC increases the amount of time in the sleep state.[8] Thus, it would seem logical to hypothesize that KC could decrease pain from procedures in neonates. Furthermore, there are reports[23-26] that mothers of neonates in the NICU are unhappy with pain management and want to participate in comforting their neonates.

One report[27] of KC being used with full-term neonates for decreasing pain response during heel lancing showed KC having a powerful effect. In that study, 30 full-term neonates were randomly assigned to KC or swaddled in bassinets to undergo the heel-lancing procedure for routine blood sampling. Crying was reduced by 82% and grimacing by 64% in the KC group vs the control group; also, the heart rate (HR) increased by 8 to 10 beats per minute (bpm) in the KC group vs 36 to 38 bpm in the control group. Based on that study of full-term neonates, we proposed using KC as an intervention for pain in preterm neonates; thus, this study tests the effectiveness of KC response to heel lancing in preterm neonates aged between 32 and 36 weeks' postmenstrual age (pma).

METHODS

The protocol and consent forms were reviewed by the constituted institutional review board of each participating center. Mothers and their preterm neonates were eligible for participation in the study if the neonates met the following criteria: born between 32⅐ and 36⅐ completed weeks pma, determined by early ultrasonography at 16 weeks; had informed parental consent; had Apgar scores of greater than 6 at 5 minutes; were within 10 days of birth; were breathing unassisted; did not have any major congenital anomalies; had not experienced a grade III or IV intraventricular hemorrhage or subsequent periventricular leukomalacia; had not undergone surgery; and were not receiving paralytic, analgesic, or sedative medications within 48 hours of study sessions. Mothers had to be willing and able to hold their neonate in the KC position for the study. For practical purposes, if the neonate was to be discharged from the hospital before needing 2 sessions of blood work, the parents were not approached to participate in the study. Using data from an earlier study[28] using our primary outcome with a mean difference of 2 points and an SD of 3.5 points, the sample size for a power of 0.8 and a significance level set at .05 was 67.

By using a single-blind crossover design, each neonate was to undergo heel lancing for blood procurement for clinical purposes in either the KC position or the usual cot situation within 4 days of each other. Ordering of conditions was determined randomly by a computer-generated program in the study center. There was a minimum of 24 hours and a maximum of 7 days between conditions, because the frequency of blood sampling was determined by clinical considerations. In the KC condition, the diaper-clad neonate was held upright, at an angle of approximately 60°, between the mother's breasts, providing maximal skin-to-skin contact between the neonate and the mother. A blanket was placed over the neonate's back and the mother's clothes were wrapped around the neonate. The neonate remained in this condition 30 minutes before the heel-lancing procedure. We asked that the mother keep her hands clasped behind the neonate's back throughout the procedure and refrain from touching the neonate's head with her face and from vocalizing to the neonate during the filming (to keep observers blind). In the isolette control condition, the neonate was placed in the isolette in a prone position, swaddled with a blanket (with heel accessible), for 30 minutes before the heel-lancing procedure. The prone position was selected because it controlled for the positional component of KC, allowing us to test the maternal proximity component, and because it is recommended for neonates who are premature.[29,30]

The heel-lancing procedure was selected as the pain stimulus for several reasons: (1) it is the most common tissue-damaging procedure that premature neonates undergo, (2) the procedure can be relatively standardized across times and staff, and (3) it is an event that occurs as part of routine care of premature neonates and is not an artificial stimulus. The same person conducted the procedure at each site. The procedure includes 5 phases: baseline (5 minutes), heel warming (1 minute), heel lancing with a spring-loaded lancet (Tenderfoot) (15 seconds), heel squeeze (30 seconds of rhythmic squeezing for each block of time, until all required blood is procured), and return to baseline (5 minutes). There was continuous videotaping and pulse oximeter monitoring of the neonate throughout the procedure, which always occurred in the morning. The continuous data were averaged for each block of time.

The primary outcome was the Premature Infant Pain Profile (PIPP).[31] The PIPP is a composite measure of pain, including physiological and behavioral indicators that were originally developed using 4 data sets of preterm neonates in a pain/no pain situation. The components are HR, oxygen saturation, 3 facial actions, neurobehavioral state, and pma. Increases in HR are scored in incremental blocks of 5 bpm, ranging from 0 (0-4 bpm) to 3 (≥15 bpm); decreases in oxygen saturation are scored in increments of 2%, ranging from 0 (<2% change) to 3 (≥6% change); and each facial action is scored in increments of a third of the time that the action is seen, from 0 (less than one third of the time) to 3 (all the time). Weights are added for being young (<28 weeks receives a score of 3) and state (quiet sleep receives a score of 3). The scores are totaled, so that with the 7 components, scores can range from 0 to 21. In earlier studies,[28] a mean difference of 2 was found (eg, when comparing sucrose with pacifier intervention vs the control condition in neonates aged 28-36 weeks' pma). In studies[32,33] of children using a 10-point scale, a change of 1 point (ie, 10%) was reported as clinically important to the children, so that a difference in PIPP scores of 2 points between conditions can be considered clinically important.[34] The PIPP has been tested for reliability, construct validity, and clinical utility, all with good results.[35] It takes into account the influencing factors of pma and baseline sleep/wake state, shown to contribute to pain response.[21,36,37] Internal consistency ranges from 0.59 to 0.76, and interrater and intrarater reliabilities are 0.89 or higher.[27]

Heart rate and transcutaneous oxygen saturation data were collected via infrared oximeter placed on the unaffected foot of the neonate and connected to a 200- or 3000-pulse oximeter (Nellcor), with a sampling rate of 100 Hz averaged on a second-to-second basis. The HR and oxygen data were fed into a computer (Pentium) via software (Satmaster; EMG Scientific, Beverly Hills, Calif) that keeps track of real time with the physiological data, allows any number of events to be marked, and notes artifacts.

The 3 facial actions (brow bulge, eye squeeze, and nasolabial furrow) of the PIPP were continuously recorded by a digital camera (model KS162; Panasonic) that allows for close-range high-

quality facial images. The camera was in close-up focus on the neonate's face, with little surrounding area, no sound, and minimal color, and turned 60° in the KC condition so as to decrease the possibility of unblinding by research assistants who scored the tapes. Research assistants, who were blinded to the purpose of the study by being told that the study was about neonatal facial actions, coded facial actions in the laboratory of the principal investigator (C.C.J.). These assistants were students from outside the department, and they conducted the coding in laboratory space reserved only for themselves or others involved so that there was minimal exposure to discussion about the study. At the conclusion of the study, they were asked what they thought the study was about and they said that they thought it had to do with pain and possibly development. Facial actions were scored according to the Neonatal Facial Coding System,[21] which provides a detailed, anatomically based, and objective description of newborns' reactions to the heel-lancing procedure. The selected facial actions were scored on a second-to-second basis. The tapes were played back in real time on a video monitor (model AG-1970; Panasonic) with stop-frame capability and clock to the fourth decimal place. Each recording session was scored 3 times, once for each of the facial actions, using a laptop computer with software developed in the laboratory that records the scores and allows for information on artifacts to be included. A final score, based on percentage of time the action was present, was calculated for the block time of interest. The neurobehavioral state component was determined according to Prechtl[38] categories of quiet sleep or quiet awake or active sleep or active awake during baseline. Age (pma) was taken from the medical record, based on early ultrasonography at 16 weeks.

Severity of illness, as a potentially confounding variable, was scored using the Score for Neonatal Acute Physiology (SNAP-II)[39]; for the 12-hour period after birth and for the 24 hours before the procedure, the SNAP-II–Perinatal Extension was used.[39] The elements for this score can be found in the medical record, and include hemodynamic, respiratory, hematologic, metabolic, electrolytic, and neurologic variables. The score has predictive validity for perinatal mortality.[39]

RESULTS

Across the 3 sites, there were 502 neonates admitted during the data collection period (April 9, 2001, to June 28, 2002). Most neonates did not meet the age criteria; of those who did meet the age criteria, 8 were to be discharged from the hospital within 48 hours, 3 were considered too ill, and 1 mother was infected. Of the 502 neonates, 172 met the selection criteria and were approached, and 108 agreed to participate. The main reason for refusal was that the parents did not want their child involved in any research (n=11). Other reasons for refusal were that the mother was too ill (n=4), the family lived too far to come in (n=4), the neonate would associate the mother with pain (n=3), too many things were going on to handle anything else (n=3), the parents did not understand French or English well enough (n=2), the parents were too busy with other children at home (n=2), the parents did not want to do KC (n=2), the father refused and the mother deferred (n=2), the parents did not want to be filmed (n=1), and the mother did not want the neonate to cry on her (n=1). For the remainder, no reason was given. Physiological and behavioral data were completed for KC and control sessions for 74 neonates. The main reasons that neonates were not included were that the neonate was discharged from the unit (n=25), the neonate did not require blood work within the time frame of the study (n=6), or there was equipment failure (n=3). The 74 neonates remaining in the study were a mean age of 33.7 weeks (SD, 1.1 weeks; range, 32.0-36.0 weeks), at birth weighed a mean of 2054 g (SD, 406 g; range, 1320-3125 g), and were generally in a state of good health (mean SNAP-II–Perinatal Extension, 6.7; SD, 9.4; range, 0-39). Of the 74 neonates, 41 (55%) were boys, 40 (54%) had a score of 0 on the severity of illness measure, and only 6 (8%) were in the second risk category (of 5 categories). There were no significant differences between those who remained in the hospital for both sessions and those who were discharged from the hospital or did not require blood work (mean age, 33.8 weeks [$P=.66$]; mean birth weight, 2110 g [$P=.17$]; mean SNAP-II–Perinatal Extension, 6.1 [$P=.76$]). No neonate had to be removed from KC because of physiological instability.

A repeated-measures analysis of covariance, with condition (KC vs isolette) as the repeated factor, order of conditions and site as additional factors, and severity of illness as a covariate, was conducted for each 30-second period following heel lancing through 2 minutes, when most (52 [70%] of 74) procedures had been completed. There were equal instances of KC and isolette conditions in the remaining time. Thirty-four neonates underwent KC before the isolette condition. There were no significant effects for site ($P=.29$) or order ($P=.54$) of condition, and severity of illness (SNAP-II and SNAP-II–Perinatal Extension) was not significant ($P=.19$). There were no significant differences in heart rate ($P=.72$) or oxygen saturation ($P=.11$) at baseline, although 62 infants (84%) in the KC condition were in quiet sleep in the isolette condition ($\chi^2_3=65.56$, $P=.000$). All facial actions were 0 during baseline. Pain scores (PIPP) were significantly lower in the KC condition at 30 seconds (difference, 1.5 points; $P=.04$), 60 seconds (difference, 2.2 points; $P=.002$), and 90 seconds (difference, 1.8 points; $P=.02$), but not at 120 seconds (difference, 0.6 point; $P=.37$), after the heel-lancing procedure (**Table**). When examined individually, HR and oxygen saturation were similar in both conditions, but the facial actions contributed significantly ($.000<P<.005$) to the total pain score, with facial actions on average 20% greater in the control vs the KC condition (**Figure**).

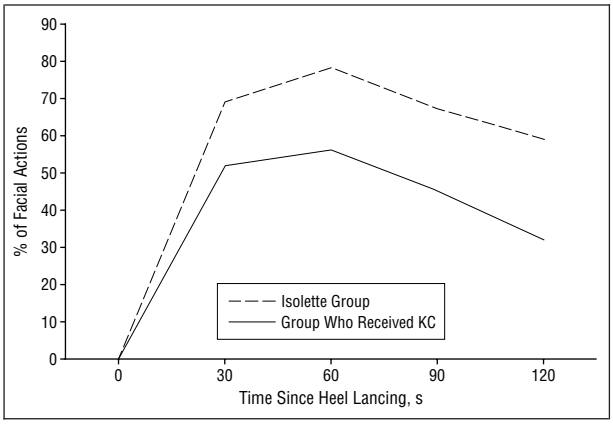
COMMENT

It seems that maternal contact in the skin-to-skin paradigm of KC is an analgesic for preterm neonates between 32 and 36 weeks' pma who are undergoing heel lancing for blood procurement. As well as statistically significant differences, the magnitude of the difference in scores between the isolette and KC conditions can also be considered clinically important.[34] The differences between isolette and KC were approximately between 1.5 and 2.2 in the first three 30-second blocks, of a total possible score of 21; thus, there was close to a 10% difference. A similar finding of the efficacy of KC for reducing procedural pain was shown earlier in full-term neonates,[27] but, to our knowledge, has not previously been shown in preterm neonates. The mechanisms could be related to state regulation, which has been reported to be a result of KC.[4-8] Maternal touch is implicated in development, and has been demonstrated

The PIPP Scores in 74 Neonates Following Heel Lancing

Condition	Time After Heel Lancing, s*			
	30	60	90	120
KC	10.1 (9.1-11.1)	10.7 (9.7-11.8)	10.3 (9.6-11.5)	10.7 (8.9-11.2)
Isolette	11.6 (10.7-12.4)	12.9 (12.1-13.8)	12.1 (11.1-13.2)	10.1 (9.5-11.9)

Abbreviations: KC, kangaroo care; PIPP, Premature Infant Pain Profile.
*Data are given as mean (95% confidence interval) scores on the PIPP.[31]



Facial actions contributed significantly (.000<*P*<.005) to the total pain score, with facial actions on average 20% greater in the isolette (control) group vs the group who received kangaroo care (KC).

What This Study Adds

The salient components of KC that are thought to promote quiet state and release endorphins are closeness, warmth, and rhythmic breathing of the mother (which provides vestibular stimulation). Kangaroo care has been shown to have analgesic effects on full-term neonates; however, before this study, it was unknown whether it would have the same effect on preterm neonates, who are less developed in state regulation.

Kangaroo care was effective in significantly decreasing pain response on the behavioral components of a validated composite measure of pain in preterm neonates. Given the many invasive procedures that are part of clinical care in preterm neonates, KC may be a safe analgesic alternative in neonates in whom it is feasible and with mothers who are comfortable providing KC for painful events.

in humans and animals.[40-43] Maternal influence has had a dampening effect on pain response in animal studies.[44,45] It could also be the neonate's recognition of the mother and that the presence of familiar stimuli was comforting. In animal studies,[46-48] it has been shown that endorphins are released on reunion with a mother following a separation. In full-term neonates, it has been shown that neonates recognize their mother's voice,[49,50] and breast milk is thought to smell similar to amniotic fluid,[51-53] so that the neonates may have recognized their mothers through olfactory and auditory senses. This sensory memory could take place earlier than 40 weeks' gestation.[50,54,55] More research is needed to understand the mechanisms of analgesia provided by maternal presence in neonates born before their due date.

There could have been some influence of position on the ability of the technicians who obtained blood to do so. The technicians reported that obtaining blood from neonates in the KC condition was more difficult than obtaining blood from neonates prone in the isolette. Therefore, if positioning had influenced the results because of facility for blood sampling, it would likely have been in the opposite direction. This may have contributed to the modest difference between conditions.

Mothers who agreed to participate in this study are mothers who were comfortable in the KC situation in a busy NICU. This could represent a selection bias in that mothers who were not as comfortable may not have been as effective in providing comfort to their neonates. Some mothers expressed concern about the potential risk of negative conditioning if KC was used repeatedly for painful procedures. In one study[36] that followed up neonates weekly for changes in their pain expression, a sham heel-lancing procedure, which included warming, was performed; from the age of 28 to 36 weeks, there was no indication of conditioning to associate heel warming with the impending lancing. More recently, Goubet et al[56] reported evidence of conditioning to heel lancing when the technician lifted the heel and held it. The increase in HR they reported could be attributed to handling, not anticipation, of heel lancing. Taddio et al[31] reported response to alcohol swabbing in full-term neonates who had undergone numerous blood samplings because of their mother's diabetes mellitus compared with neonates who had not undergone heel lancing. This is evidence of conditioning, but alcohol swabbing is a noxious stimulus, whereas being held in the KC condition is not noxious, as noted by the increased incidence of the quiet state during baseline in the KC condition vs the isolette. Comfort in distressed states is a basic maternal role, and we are unaware of any reports of neonates forming negative associations to their mothers in the context of providing comfort during a painful event.

Further study is needed to determine which groups within the NICU can benefit from this intervention. The neonates in the study were generally healthy, but perhaps even younger, smaller, and ventilated neonates could benefit.[57] Given a refusal rate of close to 40% and mothers' spontaneous expressions of concern, research into maternal attitudes on their role in relieving pain would be informative. Given that the prevalence of KC in North American NICUs[1] is high and the number of invasive procedures, especially heel-lancing procedures, is high,[10,11] based on even this single study, it would seem appropri-

ate to offer the option of KC to mothers who want to provide comfort for a heel-lancing procedure to their stable neonate older than 32 weeks' pma.

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